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*Original Article*

# Comparison of posterior vertebral column resection and anterior corpectomy and instrumentation for correcting late post-traumatic thoracolumbar kyphosis

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**Abstract:** Purpose: To compare the clinical and radiological outcomes between anterior corpectomy & instrumentation (ACI) and posterior vertebral column resection (PVCR) in correcting late post-traumatic kyphosis (LPTK) of the thoracolumbar spine. Methods: Between January 2007 and December 2012, twenty patients underwent ACI, and twenty-three patients underwent PVCR for LPTK were prospectively reviewed. The clinical records were reviewed and compared for surgical time, blood loss, functional improvement (Oswestry Disability Index, ODI), pain relief (Visual Analog Scale, VAS). The radiological records were reviewed and compared for correction of kyphotic deformity, correction loss, fusion rate, cage subsidence and cage tilting. Results: The surgery time was shorter in PVCR group than that in ACI group (156.3 ± 32.9 min vs. 188.3 ± 37.1 min, $P$=0.006), the blood loss was less in PVCR group than that in ACI group (806.5 ± 174.5 ml vs. 974.5 ± 146.1 ml, $P$=0.021), the difference of deformity correction was statistically significant in favor of the PVCR group (37.3 ± 5.2 vs. 22.3 ± 4.4, $P$<0.001). At 24 months follow-up, no statistical difference was found between the two groups in cage subsidence (2.1 ± 0.7 mm in PVCR vs. 1.9 ± 0.8 mm in ACI, $P$=0.796), anterior-posterior cage tilting (2.0 ± 0.5 in PVCR vs. 2.4 ± 0.7 in ACI, $P$=0.111), lateral cage tilting (2.9 ± 0.8 in PVCR vs. 3.2 ± 0.9 in ACI, $P$=0.342) and correction loss (2.8 ± 1.8 in PVCR vs. 2.5 ± 1.7 in ACI, $P$=0.536). All of the patients got ODI improvement and VAS relief, and no statistical difference was found between the two groups in ODI improvement (44.2 ± 5.7% in PVCR vs. 42.9 ± 5.9% in ACI, $P$=0.444) and VAS relief (5.2 ± 0.9 in PVCR vs. 5.3 ± 1.3 in ACI, $P$=0.815). Conclusions: The posterior vertebral column resection have the advantage over anterior corpectomy & instrumentation in shorter surgery time, less blood loss, and more kyphotic correction for correcting late post-traumatic kyphosis of the thoracolumbar spine.

**Keywords:** Anterior corpectomy and instrumentation, posterior vertebral column resection, late post traumatic kyphosis

## Introduction

Thoracolumbar fracture has become the commonest injury in the traumatic spinal surgery along with the increment of motor vehicle accident and fall from a height [1]. Patients with missed fractures or initial treatment failure may be at risk of developing late post-traumatic kyphosis (LPTK) [2]. Surgical intervention is indicated for patients with progressive deformity, refractory back pain, or deterioration of neurological status [3-6]. The goal of operation is to decompress the neural elements, restore vertebral body height, correct angular deformity, and stabilize the columns of the spine [7]. The required steps can be carried out via an anterior, posterior, or combined approach, and the ideal surgical procedure remains controversial.

Anterior corpectomy and instrumentation (ACI) provides good exposure for direct decompression of the spinal canal, facilitates good reconstruction of the anterior and middle portions of the spinal column, provides solid fusion, and re-establishes normal sagittal contour of the injured vertebra [8, 9]. Successful clinical and radiological outcomes after ACI for correcting LPTK have been reported [10, 11]. Posterior vertebral column resection (PVCR), involving resection of the vertebral body and adjacent discs above and below, anterior reconstruction

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 17 | 6 | 11 | 45 | 67 | 66 | 68 | 68 | 67 | 72 |
| 2 | 21 | 10 | 8 | 55 | 55 | 60 | 61 | 69 | 63 | 71 |
| 3 | 14 | 10 | 7 | 54 | 54 | 69 | 53 | 89 | 68 | 74 |
| 4 | 26 | 11 | 11 | 42 | 53 | 65 | 67 | 62 | 62 | 67 |
| 5 | 18 | 13 | 11 | 53 | 48 | 60 | 77 | 72 | 62 | 68 |
| 6 | 8 | 17 | 12 | 62 | 61 | 62 | 63 | 65 | 64 | 63 |
| 7 | 13 | 12 | 8 | 56 | 67 | 58 | 72 | 63 | 65 | 63 |
| 8 | 12 | 11 | 12 | 55 | 57 | 45 | 62 | 65 | 62 | 74 |
| 9 | 12 | 9 | 13 | 56 | 59 | 54 | 68 | 64 | 76 | 68 |
| 10 | 18 | 11 | 9 | 49 | 52 | 67 | 67 | 63 | 76 | 62 |

**Figure 1.** The random number table.

**Table 1.** The Main Features in the PVCR and ACI Group at Baseline, Before the Surgery

| Patient characteristics | PVCR | ACI | *p* Value |
|---|---|---|---|
| Number of patients | 23 | 20 | |
| Male/Female | 14/9 | 12/8 | 0.954 |
| Age (y) | 47.6 ± 5.2 | 48.1 ± 5.3 | 0.785 |
| T value | 0.9 ± 0.2 | 0.8 ± 0.3 | 0.320 |
| Duration (mo) | 31.5 ± 5.5 | 33.3 ± 7.1 | 0.364 |
| BMI | 24.3 ± 2.1 | 23.9 ± 2.2 | 0.543 |
| ODI (%) | 67.4 ± 3.7 | 65.8 ± 5.2 | 0.236 |
| VAS | 7.0 ± 1.0 | 6.9 ± 1.2 | 0.763 |
| Kyphotic angle (°) | 47.0 ± 5.7 | 45.5 ± 5.6 | 0.400 |

by a metal mesh, can both improve the kyphosis correction and reduce the incidence of dural buckling. The posterior only surgical approach is well known for its various advantages, such as safety, good surgical field of view and is familiar to spine surgeons [12].

To the best of our knowledge, this is the first study to compare the clinical and radiological outcomes of ACI and PVCR in correcting LPTK of the thoracolumbar spine.

## Materials and methods

### *Subjects*

The study was approved by Ethics Committee of The Third Hospital of HeBei Medical University. The inclusion criteria was the following: symptomatic LPTK of the thoracolumbar spine, the symptoms related to the kyphosis included intractable pain, leaning forward (stooping), rapid fatigue, and progressive neurologic deficit, focal thoracolumbar kyphosis greater than 30 degrees due to a previous vertebral body fracture (time interval >12 months); conservative treatment more than three months and did not work. The exclusion criteria: thoracolumbar spine neoplasm, infection, obvious deformity of coronal plane (scoliosis ≥10), severe osteoporosis precluding secure fixations (T<-2.5).

From January 2007 to December 2012, forty-three patients with severe thoracolumbar kyphotic deformity were prospectively reviewed. All of the patients were randomly assigned to ACI group (patients received ACI) and PVCR group (patients received PVCR), according to random number table method. First, a random number table was created by computer (**Figure 1**). Second, every patient, enrolled in this study, was asked to choose a number within the table, in a way of row (1 to 10) and column (1 to 10), then they were assigned the corresponding numbers. For example, if a patient chose row 5 and column 5, then the corresponding number was 48. Third, if the selected number was Odd, the patient was enrolled into ACI group. If the patient selected an even number, he/she was enrolled into PVCR group. All patients were provided written informed consent to participate in this study before the enrollment.

There were twenty patients received ACI and were enrolled as the ACI group, 12 male and 8 female, the mean age at the time of surgery was 48.1 ± 5.3 years (range: 38-62 years). The distribution of vertebral compression fracture was as follows: 3 patients with $T_{12}$, 11 patients with $L_1$, 6 patients with $L_2$. There were twenty-three patients received PVCR and were enrolled as the PVCR group, 14 male and 9 female, the mean age of the patients was 47.6 ± 5.2 years (range: 39-58 years). The distribution of vertebral compression fracture was as follows: 4 patients with $T_{12}$, 12 patients with $L_1$, 7 patients with $L_2$. The two groups were compatible in age, sex composition, body mass index (BMI), T

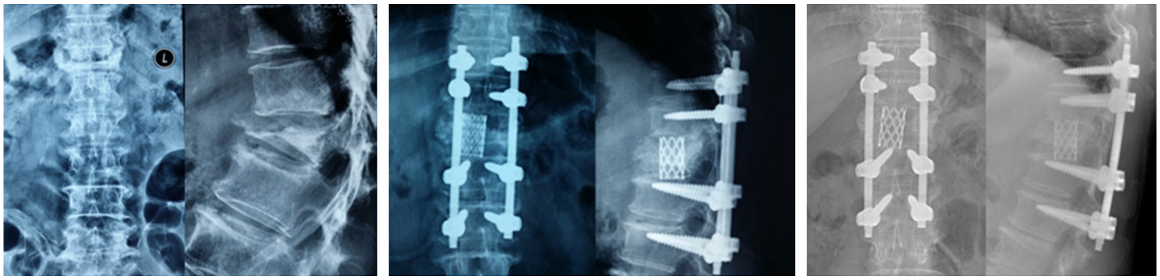

**Figure 2.** The patient in PVCR group: the preoperative kyphotic angle was 48 degrees, the kyphotic angle was 8 degrees at 2 weeks postoperative, 10 degrees at two years follow-up.

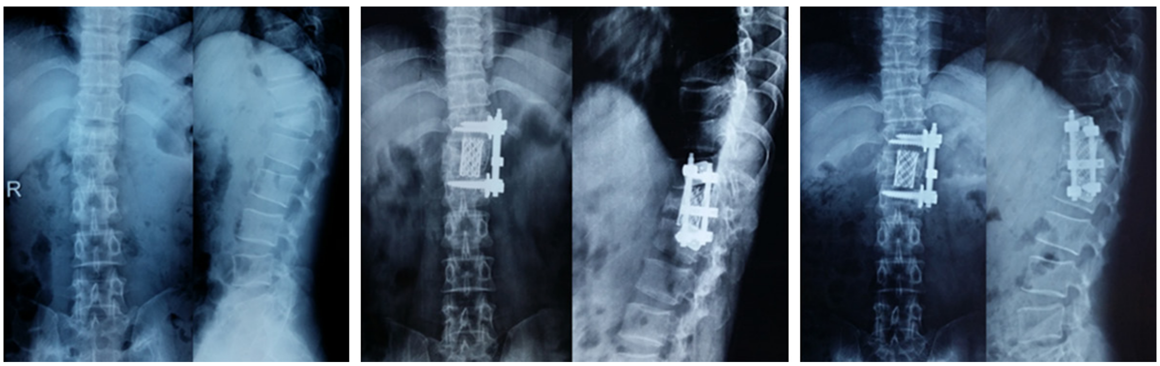

**Figure 3.** The patient in ACI group: the preoperative kyphotic angle was 46 degrees, the kyphotic angle was 25 degrees at 2 weeks postoperative, 26 degrees at two years follow-up.

value, duration from fracture to surgery, preoperative kyphotic angle, ODI and VAS (**Table 1**).

*Surgical methods*

All surgeries were performed by the same surgery team under general anesthesia. Motor and somatosensory evoked potentials (MEPs and SSEPs) were all used in every patient. The PVCR technique used was the same as described in the previous study [13]. Pedicle screws were inserted in two levels above and below the osteotomy level (for a typical case see **Figure 2**). The ACI technique used was the same as described by Benli [10]. Pedicle screws were inserted in only one level above and below the deformity level (for a typical case see **Figure 3**). Postoperatively, patients were allowed out of bed at the second postoperative week.

*Clinical and imaging evaluation*

The Oswestry Disability Index (ODI) was used to make a comprehensive and systematic evaluation of the overall physical condition and the Visual Analogue Scale (VAS) was used to assess the pain at one day pre-operation and twenty-four months post-operation. Other details, such as operative time and blood loss were collected from the clinical notes.

Anteroposterior (AP) and lateral (LA) X-rays were obtained preoperative, two weeks after surgery, and final follow-up. The angle of the deformity was measured using lines projected from the upper border of the vertebra above and lower border of the vertebra below the compressed vertebrae (**Figure 4**). The deformity correction, loss of correction, cage subsidence (**Figure 5**) and cage tilting (**Figure 6**) were measured (**Table 2**). Assessment of radiological fusion at follow-up was based on the presence of trabecular bone bridging at the osteotomy site according to Bridwell [14].

*Statistical analysis*

Statistical analysis of the data was performed using SPSS 13.0 software (SPSS Inc., Chicago, IL). Continuous variables (age, preoperative kyphotic angle, surgery time, blood loss, correction of kyphotic angle, loss of correction, ODI improvement, VAS improvement, cage tilting and subsidence) were compared using a two-

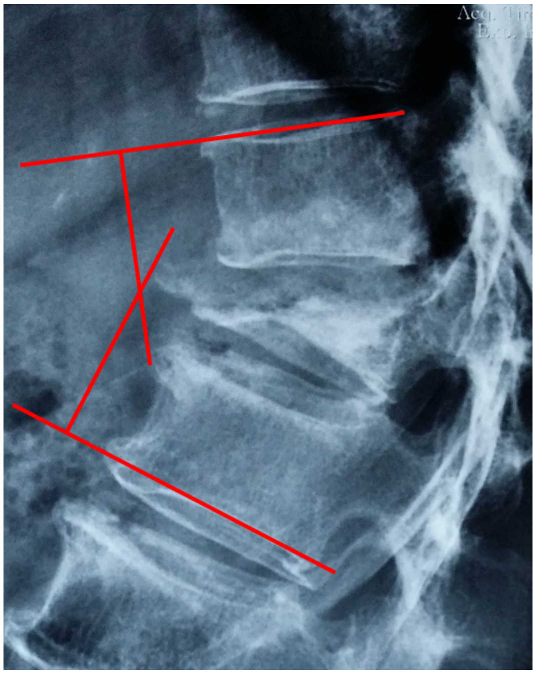

**Figure 4.** The angle of kyphotic deformity was measured using lines projected from the upper border of the vertebra above and lower border of the vertebra below the compressed vertebrae.

sample t test; Categorical variables (such as gender and anterior fusion grade) were compared using the chi-square test, values of <0.05 were considered significant.

## Results

All the patients showed no intraoperative changes in the SSEP and MEP, no severe neurological complication or vascular injury occurred either during or after surgery. The mean operating time was 156.3 ± 32.9 min in PVCR group and 188.3 ± 37.1 min in ACI group, with statistical difference between the groups (*P*=0.006). There was also significant difference between the two groups with respect to blood loss during surgery (*P*=0.021), with a mean of 806.5 ± 174.5 ml in PVCR group and 974.5 ± 146.1 ml in ACI group. The difference of deformity correction was statistically significant in favor of PVCR group (37.3 ± 5.2 vs. 22.3 ± 4.4, *P*<0.001) (**Table 3**).

At twenty-four months follow-up, no statistical difference was found between the two groups in cage subsidence (2.1 ± 0.7 mm in PVCR vs. 1.9 ± 0.8 mm in ACI, *P*=0.796), anterior-posterior cage tilting (2.0 ± 0.5 in PVCR vs. 2.4 ± 0.7 in ACI, *P*=0.111), lateral cage tilting (2.9 ± 0.8 in PVCR vs. 3.2 ± 0.9 in ACI, *P*=0.342) and correction loss (2.8 ± 1.8 in PVCR vs. 2.5 ± 1.7 in ACI, *P*=0.536) (**Table 4**). All of the patients got ODI improvement and VAS relief, and no statistical difference was found between the two groups in ODI improvement (44.2 ± 5.7% in PVCR vs. 42.9 ± 5.9% in ACI, *P*=0.444) and VAS relief (5.2 ± 0.9 in PVCR vs. 5.3 ± 1.3 in ACI, *P*=0.815) (**Table 5**).

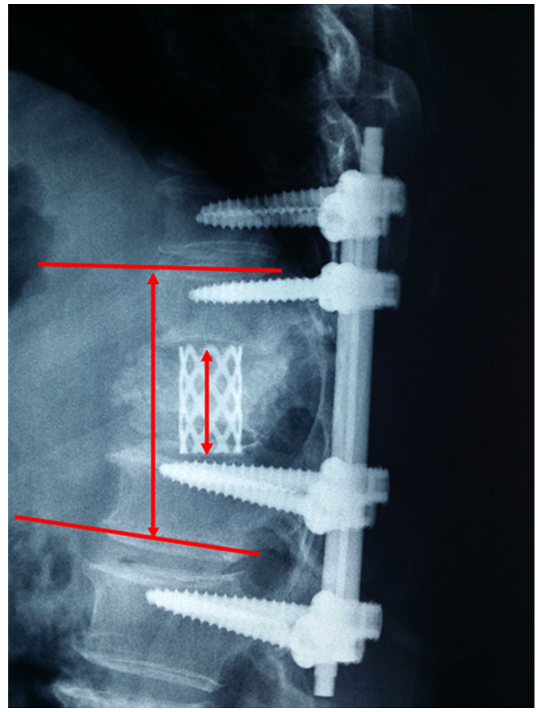

**Figure 5.** The cage subsidence: the distance from the superior endplate of the cephalad intact vertebra to the inferior endplate of the caudad intact vertebra was measured along the longitudinal axis of the cage. The difference in this measurement was used for calculating cage subsidence.

All patients achieved bony fusion on basis of presence of trabecular bone bridging at the osteotomy site at twenty-four months follow-up. Complication in PVCR group included transient left lower limb paraesthesia occurring in one patient that resolved spontaneously within one week. The complications in ACI group included an peritoneal injury (due to adhesions) in one patient that repaired intra-operatively.

## Discussion

The anterior approach has advantages including direct decompression of the spinal canal, easy placement of anterior structural support, and more bio-mechanical stability [9, 14].

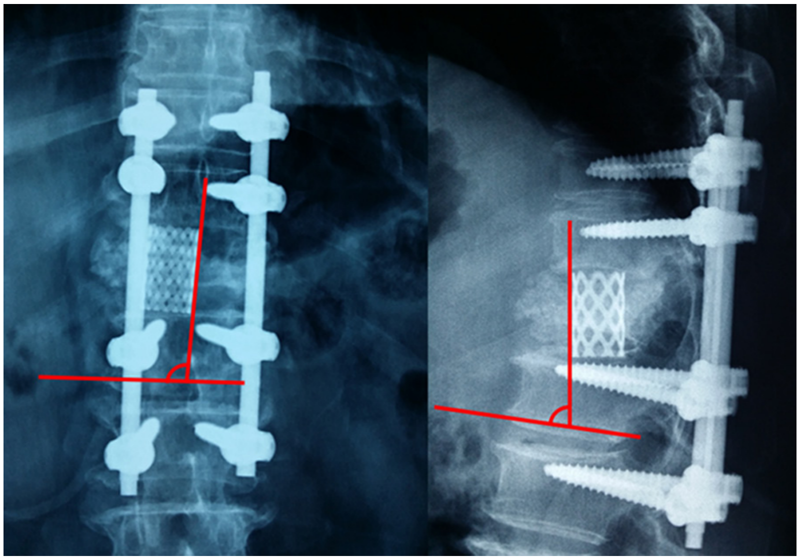

**Figure 6.** The cage tilting: the angle between the cage axis and the inferior endplate of the caudal intact vertebra was measured in both anteroposterior (left) and lateral (right) views. The difference in this measurement was used for calculating cage tilting.

However, the morbidity associated with wide retroperitoneal and thoracotomy exposures, as well as the postoperative pain are difficult to manage. Theoretically, the blood loss is significantly related to the surgical time, and the surgery time is mainly depended on the complexity of the surgery and the proficiency of surgeon to the operation. The surgery time was longer and the blood loss was more in ACI group than that in PVCR group, the relatively sophisticated and wide surgical exposure of the ACI technique may be the possible reason.

The main shortcoming of the anterior technique is the difficulty to restore the anterior column height to normal, resulting in post-operative persistence of kyphosis, at least part of this difficulty can be due to technical reasons [6]. First, a thorough release of the vertebral column, either total resection of the vertebral body or by complete soft tissue release is critical for kyphosis correction [11]. In reality, the anterior corpectomy is always subtotal. Second, If surgery is restricted to an anterior approach, correction of a deformity is often hindered by posterior structures [15]. On the contrary, laminae and bilateral facet joints of the target vertebrae are completely resected in PVCR procedure, and the sequential compression of bilateral rods provides the opportunity for restoration of anterior column height to normal. Before attempting to correct the deformity, the soft tissues around the vertebrae and within the spinal canal need to be released, then compression of the nerve roots or impingement of dural sac can be prevented at the time of correction, while this can only be carried out effectively by a posterior approach [16].

Pain is one of the main surgical indications for post-traumatic kyphosis, and it may be caused by the kyphotic deformity itself, injured disc, bony non-union, or from the lordotic compensation above or below the deformity site where added stresses are placed on the respective facet joints [17]. Both the ACI and PVCR got obvious pain relief two years after deformity correction, and no significant difference in pain relief was found between the two groups. Although the 37.3 degrees correction in PVCR was larger than that in ACI (22.3 degrees), we suppose the correction of kyphotic deformity in ACI is enough to relieve the lordotic compensation above or below the deformity site. Both the ACI and PVCR demonstrate no significant difference in preoperative ODI and ODI improvement two years after the osteotomy, this result may be attributed to the fact that most of the patients got similar pain relief and returned to normal work/ life two years after deformity correction.

Titanium cage, with the availability of different diameter, length, and with the hollow center to accommodate bone graft, is an ideal anterior struct. With the addition of rods and screws, immediate structural support and stabilization can be achieved. The cage subsidence or cage tilting is inevitable due to the sharp rim of the cage edge that leads to point loading at the cage-bone interface, these would cause acute or subacute failure and relapse of the deformity. The important technical aspect to prevent cage tilting or subsidence is the preservation of intact endplates in the vertebrae above and below the corpectomy [18]. Another aspect is

**Table 2.** The Method of Imaging Evaluation

| Variables | The method |
|---|---|
| Deformity correction | Preoperative kyphotic angle-kyphotic angle at two-week postoperative. |
| Loss of correction | Kyphotic angle at twenty-four months postoperative-kyphotic angle at two weeks postoperative. |
| Cage subsidence | The distance from the superior endplate of the cephalad intact vertebra to the inferior endplate of the caudad intact vertebra was measured along the longitudinal axis of the cage on lateral radiographs. |
| Cage tilting | The angle between the cage axis and the inferior endplate of the caudal intact vertebra was measured in both lateral and anteroposterior views. |

**Table 3.** Comparison of Clinical and Radiological Outcomes Postoperatively

| Patient characteristics | PVCR | ACI | *p* Value |
|---|---|---|---|
| Operating time (min) | 156.3 ± 32.9 | 188.3 ± 37.1 | 0.006 |
| Blood loss (mLml) | 806.5 ± 174.5 | 974.5 ± 146.1 | 0.021 |
| Kyphotic correction | 37.3 ± 5.2 | 22.3 ± 4.4 | <0.001 |

**Table 4.** Comparison of Radiological Outcomes at Twenty-four Months Follow-up

| Patient characteristics | PVCR | ACI | *p* Value |
|---|---|---|---|
| Cage subsidence (mm) | 2.1 ± 0.7 | 1.9 ± 0.8 | 0.796 |
| AP cage tilting (°) | 2.0 ± 0.5 | 2.4 ± 0.7 | 0.111 |
| LA cage tilting (°) | 2.9 ± 0.8 | 3.2 ± 0.9 | 0.342 |
| Correction loss | 2.8 ± 1.8 | 2.5 ± 1.7 | 0.536 |

**Table 5.** Comparison of Clinical Outcomes at Twenty-four Months Follow-up

| Patient characteristics | PVCR | ACI | *p* Value |
|---|---|---|---|
| ODI (%) | | | |
| Preoperative | 67.4 ± 3.7 | 65.8 ± 5.2 | 0.236 |
| 24 months follow up | 23.2 ± 6.3 | 22.9 ± 4.9 | 0.878 |
| Improvement | 44.2 ± 5.7 | 42.9 ± 5.9 | 0.444 |
| VAS | | | |
| Preoperative | 7.0 ± 1.0 | 6.9 ± 1.2 | 0.763 |
| 24 months follow up | 1.8 ± 0.7 | 1.6 ± 0.8 | 0.406 |
| Improvement | 5.2 ± 0.9 | 5.3 ± 1.3 | 0.815 |

the use of the titanium cage with the largest possible contact surface on the vertebral endplates. In the ACI, a cage with the largest diameter, which may be easily inserted into the corpectomy defect, is chosen. While in the PVCR, the diameter of the cage should be proper or not so large as in ACI, because insertion of cage from the posterior route is not easy. Both the ACI and PVCR demonstrated no significant difference in cage subsidence or cage tilting two years after the osteotomy, this result may be attributed to the fact that solid bony fusion between the anterior grafts and adjacent endplates were achieved in all the participants without failure of internal instrumentation.

Loss of the kyphotic correction is common after osteotomy procedure, and may be due to cage subsidence, cage tilting, failure of internal fixation, etc. In this study, no significant difference existed in correction loss between ACI and PVCR group, and we suppose two possible reasons may account for it. First, all the mesh cages maintained a good position throughout the two-year follow-up, without significant cage subsidence or cage tilting. Second, all the participants achieved solid bony fusion between the grafts and adjacent endplates at the final follow-up, which would eliminate the intervertebral instability and decrease the risk of failure of internal fixation.

In conclusion, the posterior vertebral column resection have the advantage over anterior corpectomy and instrumentation in shorter surgery time, less blood loss, and more kyphotic correction for correcting late post-traumatic kyphosis of the thoracolumbar spine.

#### Disclosure of conflict of interest

None.

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